IMPACT OF SALT WORKS ON THE STATUS, POPULATION OF THE GREATER FLAMINGO *PHOENICOPTERUS RUBER ROSEUS* AND THE LESSER FLAMINGO *PHOENICONAIAS MINOR* IN THE GREAT VEDARANYAM SWAMP[1]

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(*With three text-figures*)

Key words: greater flamingo, lesser flamingo, Great Vedaranyam swamp, salt water, *Tilapia*

The status, population, seasonal fluctuations, distribution of the greater flamingo and the lesser flamingo in the Great Vedaranyam Swamp are discussed. The impacts of salt works on the two species was investigated. Both species are migrants to the Swamp, but their area of origin is uncertain. Peak population of the greater flamingo was recorded during the North East Monsoon. The arrival and stay of the lesser flamingo was erratic. Interannual variations in the numbers occurred for both the species. The impact of salt works differed according to the species, and varied both spatially and temporally.

INTRODUCTION

A great deal of work has accumulated on various aspects of the biology, ecology and ethology of flamingos (e.g. Kear and Duplaix-Hall 1975, Johnson 1983, 1989). However, no detailed long term studies have been undertaken on flamingos in the Indian subcontinent, and most of the available literature give anecdotal accounts (e.g. McCann 1939, Ali 1945, 1974; Mundkur *et al.* 1989). Flamingos inhabit highly alkaline and saline lakes and are considered to be partial to salt works (Ali and Ripley 1983). However, the extent of their partiality to salt works, the type of salt works and microhabitats preferred within salt works has not been investigated. This papers deals with the populations and seasonality of flamingos of the Great Vedaranyam Swamp, and assesses the impact of salt works on them.

STUDY AREA

The Great Vedaranyam Swamp (henceforth referred to as GVS) is one of the largest (*c.* 349 sq. km) and major wintering grounds for waterbirds in South India (Ali 1963). It forms a major part of the Point Calimere Wildlife and Bird Sanctuary, Nagapattinam Quaid - e - Milleth district, Tamil Nadu state. Its camp headquarters is situated at Kodikkarai (10° 18' N, 79° 51' E), where this study was concentrated (Fig. 1).

The habitat of the GVS is varied. It has a mangrove lined lagoon in about one-third of its western portion. The other two-thirds is a continuous sheet of shallow, fresh/brackish/saline water during the monsoon and during the period of the south westerly winds. As this water spread dries up, 'flats' are created, and during very dry periods, there is water only in the Seruthalaikkadu Creek. The GVS is connected to the Palk Strait by a few openings or breaches. Waters of the River Cauvery empty into the GVS during the NE. Monsoon period through seven channels.

Salt works: Three industrial salt works and a number of small and large scale edible salt works operate in the GVS, and are concentrated mainly around Agastiyampalli.

Industrial salt works are heterogeneous in nature with a system of reservoirs (for storage and partial condensation of brine), condensers (condensation of brine) and crystallizers (harvest pans). This process gives 99% pure salt (sodium chloride). The 'liquor' left after the extraction of sodium chloride is called bittern, and is either considered a waste product, or forms the raw material for salt based chemical units.

On the other hand, edible salt works are

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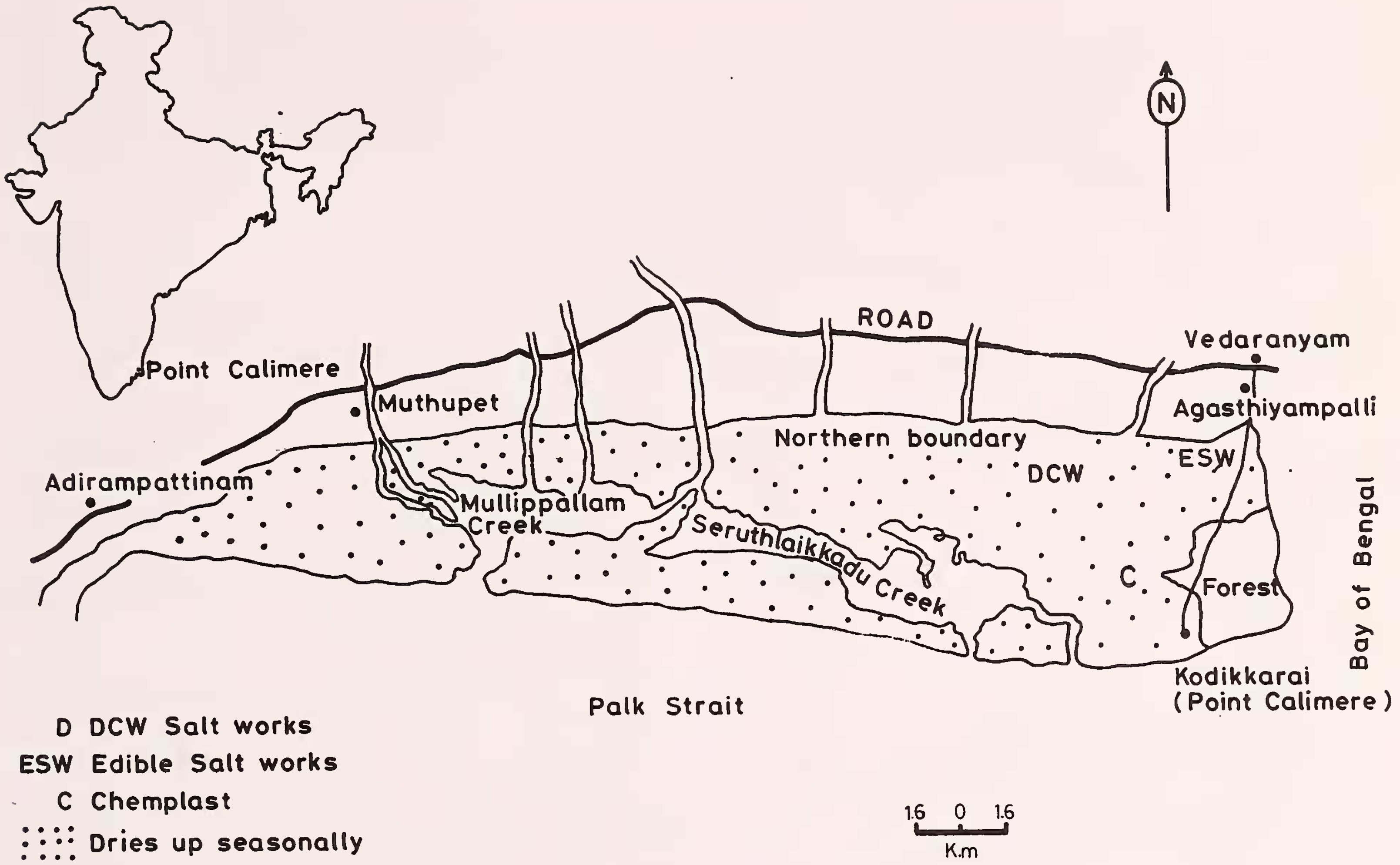

Fig. 1. Map of the Great Vedaranyam Swamp.

homogenous in nature and composed almost entirely of crystallizers, and the salt obtained by this method has impurities of calcium carbonate, calcium sulphate and salts of magnesium and potassium.

The salt season in the GVS (and the south east coast of India) is January to September. In general, during the season, salinity is lowest in the reservoirs (35-70 ppt), followed by condensers (70-230 ppt) and highest in crystallizers (240-280 ppt). Conversely, water depth is maximum in reservoirs (*c.* 40 cm), comparatively lower in condensers (*c.* 20 cm) and minimum in crystallizers (*c.* 5 cm). It should be noted that the salinity and water depth in reservoirs and condensers, besides varying from reservoir/condenser to reservoir/condenser, will again vary within itself according to the stage (early, peak and late) of the salt season. But habitat parameters in crystallizers are more or less stable temporally and spatially. The temperature of the water increases with an increase in salinity and decreases with water depth. The pH value decreases with increasing salinity due to the deposition of carbonates. Human disturbance is high (40 workers 1 sq. km) in crystallizers.

The off-season is during the NE. Monsoon period, during which, there is heavy influx of fresh water into the salt works due to the rains. Salinity falls markedly (to *c.* 10 ppt) over the whole complex. The sluice gates are opened to prevent/reduce damage to the earthern dykes and drain the complex of the low salinity water. During this time, salt works are again connected to the natural habitat. Water depth and spread in salt works depend on the stage of the monsoon — deep water during heavy rains and low water levels during dry spells (See Landry and Jaccard 1982, Britton and Johnson 1987 and Manakadan 1992 for more details).

METHODOLOGY

Total counts of greater flamingo and lesser flamingo were undertaken over an area of 19 sq. km near Kodikkarai. This area encompassed all the

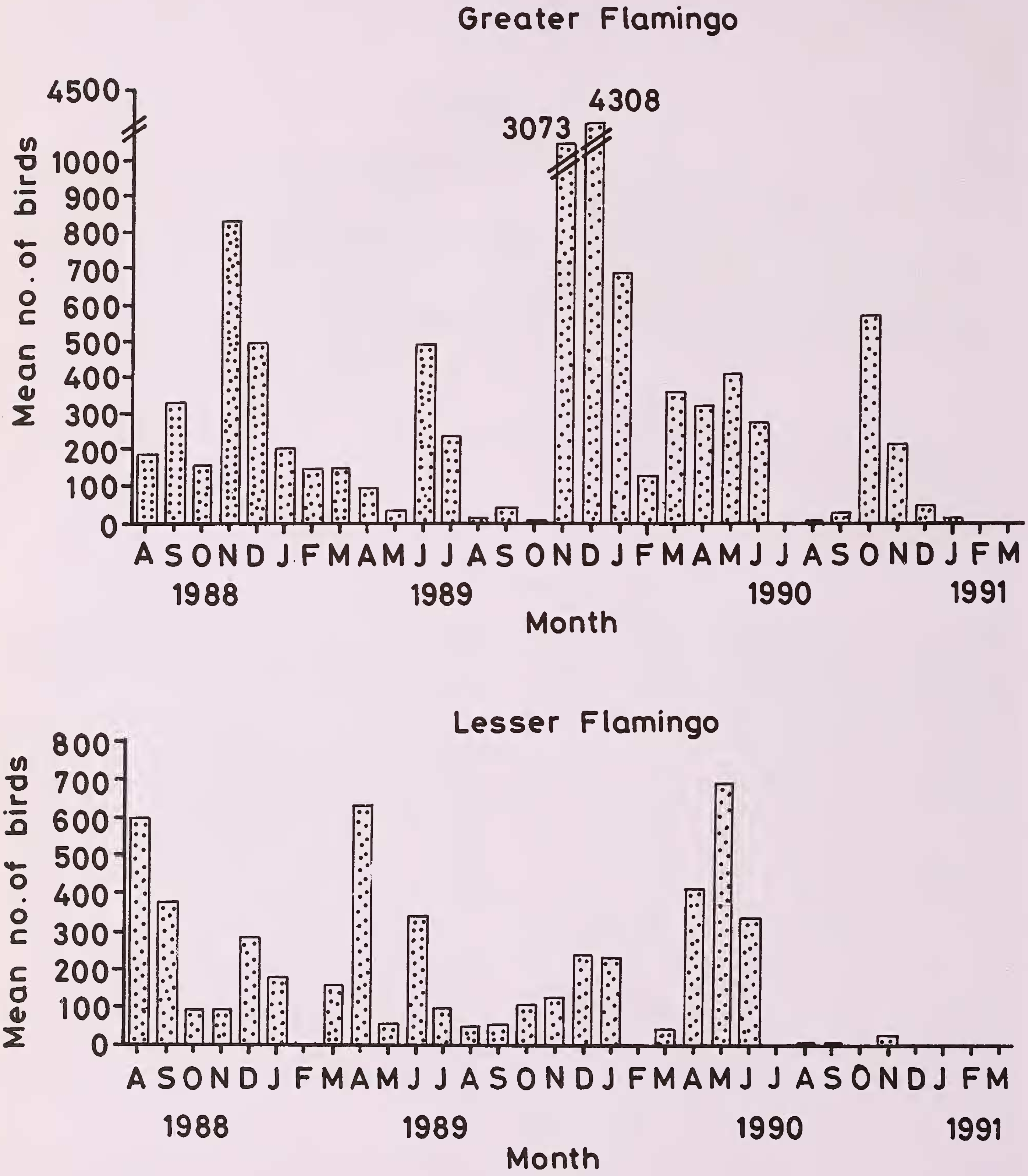

Fig. 2. Population of flamingos.

reservoirs, crystallizers and condensers of a salt work, and part of the adjoining natural habitat. Counts were done thrice a week and were conducted between August 1988 to March 1991. Accessibility to the area was by motorbike or on foot, using the dykes of the salt works. A general idea of the flamingo numbers and distribution in other parts of the GVS was obtained by occasional boat surveys and from local enquiries.

RESULTS

The greater flamingo numbers showed a marked rise in populations around the monsoon period for all the years (Fig. 2). Inter-annual fluctuations were evident, with maximum of 1650 birds in 1988, 8762 in 1989 and 676 in 1990. It was recorded in the GVS throughout the study period, except for October 1990 and March 1991. No seasonal trends were seen in the case of the lesser flamingo (Fig. 2). There were irregular monthwise fluctuations. Birds were not recorded in some months, the maximum count of 1050 birds was recorded in April 1989.

From the boat surveys and local enquiries, it appears that the flamingos are concentrated around the study area (Kodikkarai — Kodikkadu part). There was only one sighting of a flock of 300 odd lesser flamingo about 15 km west of the study area during the boat surveys. Flamingos do not frequent/ are rare in the western mangrove part of the GVS. Concentration of flamingos at the study area is probably due to the comparatively lower levels of poaching/disturbance here, due to good protection.

The greater flamingo frequented the natural habitat during the hot months or peak salt season (April-September) — except in 1989, when some birds were recorded in salt works (Fig. 3) There is a partial shift of population: 86% in 1988-89, 22% in 1989-90, 37% in 1990-91 into the salt works during the NE. Monsoon and the differences between the populations in habitats was significant for the 1989-90 season (Mann Whitney U test = 9.5, P=0.01). The birds frequent the salt complex till the early salt season or post monsoon (January till March) — 82% in 1988-89, 25% in 1989-90 and 75% in 1990-91). During their stay in salt works, significantly more birds frequented reservoirs than condensers during the 1988-89 season (U=349, p=0.001), and were recorded only in reservoirs during the 1990-91 seasons. The greater flamingo was not recorded in crystallizers. Low and contrasting values for salt works during the 1989-90 period are as follows: Just prior to the monsoon, a breach occurred in the effluent canal. This resulted in the bittern being pumped into the reservoir along with the brine — till the breach was finally plugged after three days. This caused massive kills of fish and other organisms in the reservoirs. These deaths could have prevented 'normal' build-up of prey populations as in the other years.

The lesser flamingo was partial to the natural habitat and was not recorded in salt works, except during the monsoon and post monsoon of the 1988-89 season (Fig 3). During these two cases, birds were recorded only in the reservoirs — not in condensers or crystallizers.

DISCUSSION

1. Status, seasonality and populations:

The origin of the two flamingo species of the GVS is uncertain. The earlier general presumption that they originate from Kutch has been belied by the recovery of Iranian and Russian ringed greater flamingos from the GVS [BNHS (Bird Migration Studies): unpublished data]. Major banding studies showed migration of greater flamingos from Russia to Iran during extreme cold weather (Cramp and Simmons 1977) and from Iran to the Indian subcontinent (Cramp and Simmons 1977, Johnson 1989). The lesser flamingo is presumed to be of African origin since little breeding has been recorded in India (Cramp and Simmons 1977, Ali and Ripley 1983). No information has come from the hundred odd birds (majority of them greater flamingo) ringed in the GVS by the BNHS, nor the 192 greater flamingo young ringed in Kutch (Ali 1945).

Earlier accounts of flamingos from the GVS (Ali 1963, 1986; Spillett 1969, Ali and Hussain 1981, Ali and Sugathan 1985) suggest wide seasonal and

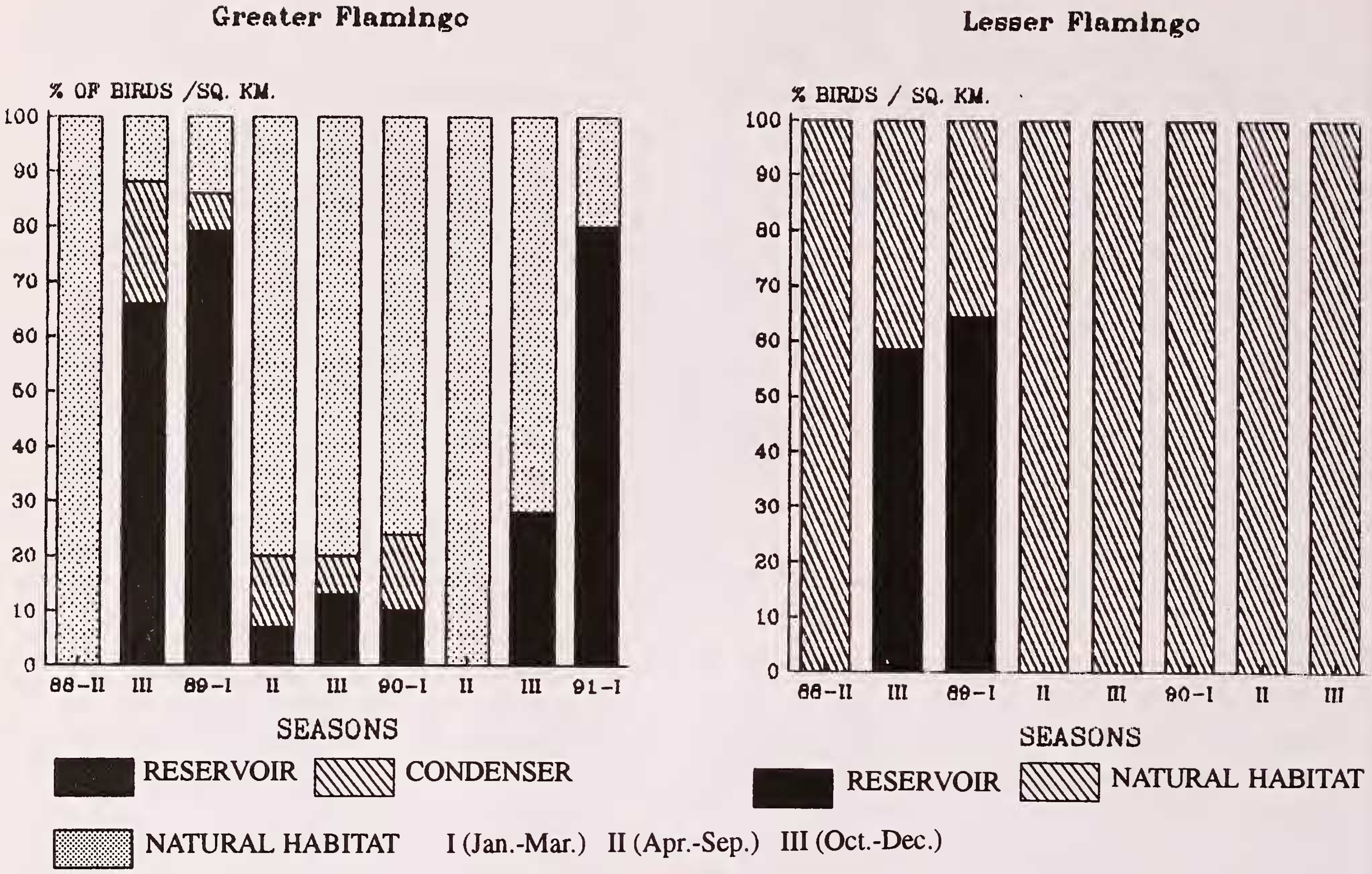

Fig. 3. Habitat utilisation by flamingos.

annual variations in the number of flamingos, as was recorded during this study. Erratic movements in flamingos are well known (Cramp and Simmons 1977, Brown *et al.* 1983, Johnson 1989), in addition to individual differences in movement pattern (Johnson 1989). The greater flamingo appears to be largely a monsoon visitor to the GVS, as reported for South India (Biddulp 1938) and Sri Lanka (Hoffmann 1989). The movements of the lesser flamingo in the GVS is similar to that described by Brown *et al.* (1983) for Africa — "sedentary for some months — then moving to other haunts."

2. Impact of salt works:

Salt works are known to be attractive to the greater flamingo during heavy rains (Connor 1980). There are two likely reasons for the shift of the greater flamingo into salt works during the monsoon in the GVS: (1) increased food supplies in salt works and (2) decreased food supplies in the natural habitat.

The favourable season for most animal communities in salt works and saline lakes is during the rainy season (Baid 1968, Mahoney and Jehl 1985, Britton and Johnson 1987). The same has been documented in the case of benthic fauna in the salt works studied (Sampath 1989), who also found the productivity to be higher in reservoirs than condensers and the natural habitat during the same period. This explains the shift of the greater flamingos into salt works (and to a greater degree into reservoirs) from the natural habitat during the monsoon. In contrast, the inflow of fresh water into the natural habitat kills off the estuarine forms as known in studies on estuarine systems (e.g. Flint and Rabalais 1981, Kalke 1981, Mathews 1981). This was found true for plankton and benthic fauna of the GVS (Anbazhagan 1989 and Godfred 1992), though not supported by Sampath's (1989) studies. Hence, a combination of increased food availability in salt works combined with decreased prey availability in the natural habitat, is responsible for the shift of greater flamingo from the natural habitat into the salt works.

As the unfavourable conditions return to salt works with the onset of the salt season, the greater flamingo returns to the natural habitat. Meanwhile, food supplies too have increased in the natural habitat due to the return of estuarine conditions (Anbazhagan 1989, Godfred 1992). But, the availability of salt tolerant species in salt works or saline lakes, that can occur in high densities due to absence of predators like fish (Mahoney and Jehl 1985) has to be considered. In very high salinity condensers (or habitats), Ephydrid larva becomes inaccessible to the greater flamingo due to the crust of gypsum formed in the beds (Hurlbert and Keith 1979, Rooth 1982). With regard to *Artemia* — another salt tolerant form and favoured food of the greater flamingo (Cramp and Simmons 1977, Ali and Ripley 1983, Britton *et al.* 1986) — its abundance is during favourable conditions, i.e. moderate salinity (Baid 1968, Mahoney and Jehl 1985, Sampath 1989). And finally, since the greater flamingo's diet is made up of largely animal than plant matter (e.g. Jenkin 1957, Cramp and Simmons 1977, Ali and Ripley 1983, Brown *et al.* 1983), the abundance of algae in high salinity areas of salt works are not particularly attractive to them.

The lesser flamingo's diet is largely composed of blue-green algae and diatoms, and it is considered to be more partial to highly saline and alkaline lakes than the greater flamingo (Jenkin 1957, Cramp and Simmons 1977, Ali and Ripley 1983, Brown *et al.* 1983). I suggest two reasons for their avoidance of salt works in this study, though saline lakes/salt works are known to be rich in algal production (Barnes 1980, Borowitzka 1981, Hammer 1981, Brock and Shiel 1983): (1) water depth and (2) presence of a food competitor.

In this study, the lesser flamingo was recorded to feed in very shallow water (< 5 cm). This water depth is generally available in many areas of the natural habitat — except in the Seruthalaikkadu Creek and during the peak monsoon period. In salt works (except for crystallizer), shallow water is limited to the edges of the reservoirs and condensers when water levels are low. To cite an example of preference for shallow water, during all the few sightings in salt works, they fed at the edges of the reservoirs or while standing on a submerged abandoned dyke of the first reservoir. The lesser flamingo is known to swim and feed in deep water, but this occurs in still water (Kahl 1970, Cramp and Simmons 1977, Brown *et al.* 1983), otherwise, the birds group and form 'rafts' to still the water. I presume such a foraging strategy is unsuitable in the GVS, due to the prevalence of windy weather because of the coastal location and effect of tides (versus inland lakes in Africa) and the absence of huge flocks or populations, as seen in Africa to be able to 'calm' the water (see Kahl 1970 and Brown *et al.* 1983). In the case of crystallizers, the presence of workers and the predominant occurrence of unicellular forms of algae (see Baid 1968, Borowitzka 1981, Jones *et al.* 1981, Brock and Shiel 1983), that the lesser flamingo is not able to extract for food (Vareshi 1978), are deterrents inspite of its shallowness.

Though often overlooked, strong competitive interactions among distantly distributed organisms is widespread (see Hurlbert *et al.* 1986). A factor known to limit flamingo populations is fish — by competing for the same prey. There seems to be a strong positive correlation between the absence of fish and flamingo populations (Ridley 1954, Hurlbert *et al.* 1986). Though Vareshi (1978, 1979) found no detectable impact on introduction of *Tilapia grahmani* in Lake Nakuru on the lesser flamingo (though both fed on a common food base), Brown *et al.* (1983) considered the introduction responsible for non-occurrence of previously recorded huge populations of the lesser flamingo. In this study, it was found that the exotic fish *Tilapia mossambicus* is concentrated in the low salinity condensers (recorded till 100 ppt). Reasons for its abundance in low salinity condensers is probably due to abundance of blue-green algae (which predominates in this salinity range — Borowitzka 1981), as blue green algae is the main or favoured food of *Tilapia mossambicus* (see Abayasiri and Costa 1978). Hence, in addition to water depth, the lesser flamingo avoided low salinity condensers due to the presence and abundance of a food competitor.

CONCLUSION

In the case of the greater flamingo, reservoirs and low salinity condensers offer an important source of food during the monsoon and post-monsoon period. The greater flamingo largely avoids salt works during the peak salt season (April to September). Crystallizers are avoided throughout the year. To the lesser flamingo, salt works result in an almost total loss of habitat.

The main reason for these differences in impacts on the two species is that the greater flamingo is a generalist feeder and can shift to feeding on the different species of prey, where and when abundant. On the other hand, the lesser flamingo is a specialist feeder of blue green algae. This dependance on a very narrow food base, restricts it from opportunistic feeding on other abundant organisms, unlike in the case of greater flamingo.

An interesting finding is that industrial salt works are more attractive to flamingos (and other birds) than edible salt works. This is because industrial salt works are heterogenous in nature and provide a varied mix of physical, chemical and biological conditions, to suit the diet or foraging strategy of the bird species. On the other hand, edible salt works are homogenous in nature and offer very harsh and non-diverse conditions almost throughout the year for most bird species.

Finally, it has to be stressed that the findings are applicable to salt works on the south-east coast of India. Habitat conditions and impacts could differ significantly in other areas. For example, while the peak season of flamingos coincides with the off-season of salt works in the GVS, the same period (October-December) is the peak salt season for salt works on the west coast of India — as the rainy season on the west coast is during June-September (SW. Monsoon).

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REFERENCES

ABAYASIRI, R.R. & H.H. COSTA (1978): The hydrobiology of Colombo (Beira) Lake VII: The food and feeding ecology of *Tilapia mossambica*. *Spolia Zeylan. 32*: 88-105.

ALI, S. (1945): More on the flamingo in Cutch. *J. Bombay nat. Hist. Soc. 45*: 586-592.

ALI, S. (1963): Point Calimere as a refuge for wintering shorebirds. *J. Bombay nat. Hist. Soc. 60*: 458-460.

ALI, S. (1974): Breeding of the lesser flamingo *Phoeniconaias minor* (Geoffroy) in Kutch. *J. Bombay nat. Hist. Soc. 71*: 141-144.

ALI, S. (1986): Studies on the movement and population structure of Indian avifauna: Annual Report (1985-1986). Bombay Natural History Society, Bombay.

ALI, S. & S.A. HUSSAIN (1981): Studies on the movement and population structure of Indian avifauna: Annual Report I. Bombay Natural History Society, Bombay.

ALI, S. & S.D. RIPLEY (1983): Handbook of the Birds of India and Pakistan. Compact edition. Oxford University Press, Delhi.

ALI, S. & R. SUGATHAN (1985): Studies on the movement and population structure of Indian avifauna: Annual Report (1984-1985). Bombay Natural History Society, Bombay.

ANBAZHAGAN, P. (1989): Hydrobiology and benthic ecology of Kodikkarai Coastal Ecosystem. Ph.D. thesis, Annamalai University, Chidambaram.

BAID, I. (1968): The arthropod fauna of Sambhar Lake, Rajasthan, India. *Oikos 19*: 293-303.

BARNES, R.S.K. (1980): The unity and diversity of aquatic systems, pp. 5-23. *In*: Fundamentals of Aquatic Ecosystems, (Eds. R.K. Barnes and K.H. Mann), Blackwell Scientific Publications, Oxford.

Biddulp, C.H. (1938): The birds of Rameswaram island. *J. Bombay nat. Hist. Soc. 40*: 238-256.

Borowitzka, L.J. (1981): The microflora: Adaptations to life in extremely saline lakes. *Hydrobiologia 81*: 33-46.

Britton, R.H., E.R. Groot & A.R. Johnson (1986): The daily cycle of feeding activity of the greater flamingo in relation to the dispersion of the prey Artemia. *Wildfowl 37*: 151-155.

Britton, R.H. & A.R. Johnson (1987): An ecological account of a Mediterranean salina — The Salin de Giraud, Camargue (S. France). *Biological Conservation 42*: 185-230.

Brock, M.A. & R.J. Shiel (1983): The composition of aquatic communities in saline wetlands in Western Australia. *Hydrobiologia 105*: 77-84.

Brown. L.H., E.K. Urban & K. Newman (1983): The Birds of Africa. Vol I. Academic Press, London.

Connor, M.A. (1980): Development of energy and mineral resources and its effects on bird conservation in southern Africa, pp. 389-406. *In*: Proc. IV Pan African Orni. Congress, Mahe (Ed. D.N. Johnson), South African Ornithological Society, Johannesburg.

Cramp, S. & K.E.L. Simmons (1977): Handbook of the Birds of Europe, the Middle East and North Africa: The Birds of the Western Palearctic. Vol I. Oxford University Press, London.

Flint, R.W. & S.C. Rabalais (1981): Estuarine benthic community dynamics related to freshwater inflow to the Corpus Christi Bay Estuary. pp. 489-507. *In*: Proceedings of the National Symposium on Freshwater Inflow into Estuaries (Eds. R. Cross and D. Williams). U.S. Fish and Wildlife Service, Office of Biological Services, FWS/OBS -81/04, 2 volumes.

Godfred, P. (1992): Ecology of Point Calimere Sanctuary (An Endangered Ecosystem). Final Report. Bombay Natural History Society, Bombay.

Hammer, T. (1981): Primary production in saline lakes. *Hydrobiologia 81*: 47-57.

Hoffmann, T.W. (1989): Notes on the status and distribution of some birds in Sri Lanka as listed in S.D. Ripley (1982): A Synopsis of the Birds of India and Pakistan, together with those of Nepal, Bhutan, Bangladesh and Sri Lanka. *J. Bombay nat. Hist. Soc. 86*: 7-16.

Hurlbert, S.H. & J.O. Keith (1979): Distribution and spatial pattering of flamingos in the Andean altiplano. *Auk. 96*: 328-342.

Hurlbert, S.H., W. Loayza & T. Morena (1986): Fish-flamingo plankton interactions in the Peruvian Andes. *Limnol. Oceanogr. 31*: 457-468.

Jenkin, P.M. (1957): The filter-feeding and food of flamingos (*Phoenicoptera*). Phil. Trans. Royal. Soc. London. Series B. Biological Sciences No. 674, Vol. *240*: 401-493.

Johnson, A. (1983): Etho-ecologie du flamat rose (*Phoenicopterus ruber roseus* Pallas) en Camargue et Dans L' ouest Palearctique. Ph.D. thesis presented to A. L' Universite Paul Sabatier De Toulouse (Sciences).

Johnson, A.R. (1989): Movements of greater flamingos in the Western Palearctic. *Rev. Ecol. (Terre Vie) 44*: 75-94.

Jones, A.G., C.M. Ewing & M.V. Melvin (1981): Biotechnology of solar saltfields. *Hydrobiologia 82*: 391-406.

Kahl, M.P. (1970): East Africa's Majestic Flamingos. *National Geographic 137*: 276-294.

Kalke, R. (1981): The effects of freshwater inflow on salinity at four stations in the Neuces-Corpus Christi and Capano-Aransas Bay systems, Texas. pp. 454-471. *In*: Proc. of the National Symposium on Freshwater Inflow to Estuaries (Eds. R. Cross and D. Williams). U.S. Fish and Wildlife Service, Office of Biological Services, FWS/OBS-81/04.

Kear, J. & N. Duplaix-Hall (Eds.) (1975): "Flamingos". T. & A.D. Poyser, Berkhamsted, Great Britain.

Landry, J.C. & J. Jaccard (1982): Chimie des eaux libres marais Salants de Salin-de-Giiraud (Sud de la France). *Geol. Medit. 9*: 329-348.

Mathews, G.A. (1981): The effects of floods on the zooplankton assemblage of San Antonio Bay, Texas during 1972 and 1973, pp. 509-525. *In*: Proc. of the National Symposium on Freshwater Inflow to Estuaries (Eds. R. Cross and D. Williams). U.S. Fish and Wildlife Service, Office of Biological Services, FWS/OBS-81/04.

Mahoney, S.A. & J.R. Jehl, Jr. (1985): Adaptations of migratory shorebirds to highly saline and alkaline lakes: Wilson's Phalarope and American Avocet. *Condor 87*: 520-527.

Manakadan, R. (1992): Ecology of waterbirds of Point Calimere Sanctuary with special reference to impact of salt works. Ph.D. thesis, Bombay University, Bombay, India.

McCann, C. (1939): The flamingo. *J. Bombay nat. Hist. Soc. 41*: 12-38.

Mundkur, T., T.R. Pravez, S. Khachar & R.M. Naik (1989): Hitherto unreported nest site of lesser flamingo *Phoeniconaias minor* in Little Rann of Kutch, Gujarat. *J. Bombay nat. Hist. Soc. 86*: 281-285.

Ridley, M.W. (1954): Observations on the diet of flamingos. *J. Bombay nat. Hist. Soc. 52*: 5-7.

Rooth, J. (1982): A manmade breeding sanctuary of flamingos on Bonaire, Netherlands, Antilles, pp. 172-176. *In*: Managing Wetlands and their Birds (Ed. D.A. Scott), IWRB, Slimbridge.

Sampath, K. (1989): Studies on the ecology of shorebirds (Aves: Charadriiformes) of the Great Vedaranyam Salt Swamp and the Pichavaram Mangroves of India. Ph.D. thesis, Annamalai University, India.

Spillett, J.J. (1969): A report on wildlife surveys in south and west India. *J. Bombay nat. Hist. Soc. 65*: 658-659.

Vareshi, E. (1978): The ecology of Lake Nakuru-I. Abundance and feeding of the lesser flamingo. *Oecologia (Berl.) 32*: 11-35.

Vareshi, E. (1979): The ecology of Lake Nakuru-II. Biomass and spatial distribution of fish. *Oecologia (Berl.) 33*: 321-335.